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ABSTRACT

The various methods of adaptive instruction can provide college faculty with options for tailoring educational experiences according to the learning situation. In conventional, lecture-type instruction, the pace and difficulty level is the same for all students, allowing for no individualization. By encouraging the students to take responsibility for certain facets of instruction, flexibility can be built into courses, adapting to individual pace, interests, and learning style. Three types of fully adaptive systems have become well-known, each with advantages. In each of the instructional systems, the instructor arranges the conditions for learning but, to some degree, leaves the major decisions about when, where, and pacing, up to the student. Programmed Instruction (PI) was developed by B. F. Skinner in the 1950s. It is characterized by learning frames, teacher-developed units of instruction that use positive reinforcement and immediate feedback. F. S. Keller, a follower of Skinner, developed the Personalized System of Instruction (PSI), which has the following components: (1) self pacing; (2) unit perfection; (3) former students as proctors; (4) emphasis on written materials; (5) criterion-referenced testing and grading; and (6) retesting for achieving mastery. Although student procrastination is a problem in PSI, studies comparing this method with conventional classes overwhelmingly favored PSI. The third adaptive instruction model is computer assisted instruction, a system that demands knowledge of equipment (hardware) and programs and methods (software). Depending on the program, computers are interactive and flexible, have infinite patience, and can be prescriptive--an excellent method for drilling and practice. All three methods can be successfully incorporated into an existing mode of instruction. (FG)

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Models of Adaptive Instruction:

A Handbook for College and University Teachers

Steven M. Ross and Mark Wasicsko

Developed for Freed-Hardeman College, Title III Grant
"Strengthening Developing Institutions Program"
July 15, 1981.

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Table of Contents

	Page
Preface	ii
Chapter I: What is Adaptive Instruction and How Much do I Want?	1
Model 1: The Conventional.	2
Model 2: Mixed Model	3
Model 3: The Full Adaptive	4
Chapter II: Programmed Instruction: A Pioneering Method	7
Chapter III: PSI: A Management System in Individualized Instruction.	13
Chapter IV: CAI: Promise for the Future	22
Closing Thoughts	31

PREFACE

The purpose of this manual is to acquaint college teachers with some of the methods and current trends in individualized instruction. The authors acknowledge that there is no one correct way to individualize instruction. What is possible and desirable to achieve in one situation can be totally ineffective and undesirable in another. Recognizing this, the present goal will be to help you to choose what is most desirable for your course, rather than to present any particular methods as "best." Presentation will, however, include commentary on what the authors have perceived to be strengths and weaknesses of the different methods. Otherwise, we would fail to capitalize on the insights that actual experiences have provided. But, in the end, the choice of how and to what extent to pursue individualization is yours alone. Research indicates that methods selected by and imposed by others will probably not work nearly as well. It is hoped that this manual will provide a useful resource for making an informed and ultimately satisfying decision in that regard.

The authors wish to thank Dr. Yvonne Ralston-Carroll of Memphis State University and Dean B.J. Naylor of Freed-Hardeman College who, as project supervisors, provided encouragement for this project. Hopefully, faculty and students from both institutions will benefit from the perspectives on adaptive learning it provides.

CHAPTER I

What is Adaptive Instruction and How Much of it do I Want?

There is no need to toss about fancy, technical terms in discussing the concept of adaptive instruction. It is what it appears to be--a way of individualizing learning. Specifically, adaptive means tailoring or selecting or prescribing educational experiences in accord with the unique characteristics of the learner. It means asking and answering such questions as: What motivates or interests the learners? What are their aptitudes? What learning procedures or methods will they react most positively to? What mode or style of learning do they use the best?

Perhaps you are shaking your head as you read these questions, muttering that such is much more easily said than done. If so, no need to apologize because you are absolutely right! Many a dissertation and research project has been devoted to "discovering" the ideal ways to teach students who have been classified as possessing certain traits or needs. Most have found those ideal methods to be elusive, and if identified, so impractical that any teacher would quickly look for other employment rather than attempt to use them.

Nevertheless, to many instructors (the authors included), the idea of adaptive instruction--whether or not it can be fully achieved--comprises a most attractive and healthy philosophy of education. It reminds us of the uniqueness of individuals, and keeps us searching in the midst of existing failure and frustration for methods that can work with each student. Interest in adaptive instruction has also led to the development of alternative teaching models that are being used everyday, with success, in virtually all

instructional contexts. In the pages to follow, we will present these approaches for you to consider. First, however, let us set the stage by describing some common (and not so common) classroom orientations on a continuum from most to least adaptive. Three general categories will be noted: (1) conventional, (2) the mixed model, and (3) the full adaptive model. Which one do you presently use? Find out by considering the following descriptions.

Model 1: The Conventional

Nonadaptive instruction is clearly the most commonly used orientation at colleges and universities. Its pervasiveness says less about the individual instructors and how they feel about students than it does about tradition and the difficulty of fostering change. It is exemplified by the highly familiar lecture-type format, in which instructors present lessons to audiences of students. The lecture approach has a great many advantages--criticizing it is not our purpose here. But, despite the positive qualities it might have, it comprises a nonadaptive model. Why? Here are some considerations made in reference to a prototypic lecture course.

1. The pace of the lecture is the same for all students. Those with good understanding of the material might become bored; those with poor understanding might find the presentation too fast.
2. The difficulty level (e.g., the vocabulary used, sophistication of examples, etc.) also is the same for all students.
3. Course completion rate is the same for all students. Fast learners, for example, must throttle back and proceed at a pace below their optimal learning rate, while for slower students "the harder they work the more behind they get."
4. Unless the class is very small, personal contact with the instructor is infrequent. Further, in-class and out-of-class projects and assignments are generated for the class as a whole, not out of concern for the individual learners.

5. When norm-references testing (grading on a curve) is used, the standard for grading becomes the class performance rather than some set criterion attainable by all. A student may study hard and get most of the questions right, but end up at the low end of the curve with a low grade just because everyone else happened to do a little bit better.

In summary, the most popular method of college teaching, the conventional lecture class, is essentially nonadaptive. Instruction, testing, remediation, and grading are selected for the class as a whole rather than for individuals.

Model 2: Mixed Model

Many courses which follow traditional lecture formats nevertheless include adaptive features. The features provide individuals with options that are not available in Model 1. However, important matters such as presentation and sequencing of content, test and course completion times, etc. remain the same for all students.

Picture a course that uses a lecture model and holds regular class sessions at stipulated times during the week. Some adaptive features that might be offered include:

1. the availability of special learning packages--programs that students who miss a lecture or need remediation can study on their own time. (Such packages may also include media resources such as films, slides, tapes, etc.).

2. the availability of audio (or audio-visual) tapes of lectures for use by students who miss a class, need extra practice, etc.

3. scheduling of help-sessions at which students can receive assistance with their lessons.

4. use of contracting in which students can select what activities they are willing to perform (e.g., whether or not to do a term paper) and thus what grade they can earn in the course.

5. outside projects or papers which allow students to select topics according to their own interests.

6. use of different testing options (e.g., exempting an A student from the final, permitting retests) which allow some flexibility according to individual needs.

7. assignment of a self-instructional module to be completed outside of class with evaluation to take place whenever individuals indicate readiness. Computer-assisted instruction (CAI) seems an ideal resource for this type of learning experience.

In summary, just because you may be restricted to or prefer a conventional lecture situation does not mean that all students need to be treated the identical way. Through incorporation of some or all the above procedures, substantial adaptation--even for large classes in formal settings--is possible. All that we are doing is building flexibility into our courses to offer sensitivity to individual differences (e.g., in pacing, interests, learning style, etc.). A potential product is increased student satisfaction and maybe better learning. Let's turn now to the case in which the instructor puts the lecture podium in storage for a while and places the student almost completely in charge of his/her own progress and activities.

Model 3: The Full Adaptive

Use of the term full adaptive can be fully misleading if taken to mean that every student has every (or most every) personal need attended to. Rather, it is intended to describe models in which instructors arrange the conditions necessary for learning, but leave the major decisions about activities (e.g., when, where, and how fast learning occurs) up to the student. Since the most commonly used program of this type, Personalized System of Instruction, will be discussed in detail in a subsequent chapter, the description here will be brief.

Picture a course in, say, college algebra that is being taught to a class of 40 students. Under the nonadaptive mode (lecture-discussion), students obtain information in class and take tests, everybody at the same time. Under the full adaptive model, presentations equivalent to class lectures might instead be made available in written manuals, audio-tapes, or computerized

lessons. Instead of attending class, students are held responsible for learning the material on their own, and then taking a competency test when they're finished. The faster the student works, the faster the course is completed. Grading can be handled in different ways, but a common procedure is to base final course grades on the number of units on which "competency" is attained. But what does the instructor do to earn his keep? Actually, a whole lot! Materials need to be arranged and continually updated. Testing becomes more frequent and much more demanding in the way of scoring and preparation. But, also, teaching abilities can come directly into play in the form of tutoring, conducting help sessions, and giving occasional lectures. More will be said about specific procedures later. Listed below are brief summaries of the most popular contemporary systems that meet our criteria of full adaptive:

1. Personalized System of Instruction (PSI): Students learn material on their own, typically from written manuals. Record-keeping and supervision are controlled by the instructor and course assistants. PSI is currently very popular at colleges and universities as an alternative to lecture-discussion.

2. Computer-Managed Instruction (CMI): could take essentially the same form as PSI, but record-keeping functions and some decision-making are relegated to the computer. We can picture a situation in which a student completes a test and submits it to an optical scanner for computer scoring. The score is immediately obtained and kept on record as part of the student's file. But, the computer is also programmed to analyze the score and generate an appropriate prescription. For example, the student may be told, "Your score is 80%, but you are weak in fractions. It is recommended that you review Manual #3 before progressing to the next unit." CMI is used mostly in the military and very little in higher education. It may be something to look for in the future.

3. Computer-Assisted Instruction (CAI): Use of the computer is extended from management and prescription only to actual teaching (delivery of material). That is, instead of reading a manual, the student receives instruction at the computer terminal. Some large scale CAI systems, namely, PLATO and TICCIT, are being used at some colleges and universities. Presently, the vast majority of instructors have had little contact with CAI. But, new developments involving availability of

> microcomputers and better learning packages are bringing about rapid changes (some say a revolution). CAI may not be something you choose for your course, but as far as education in general is concerned, it is definitely here to stay. More about this later...

In summary, the full adaptive models make it possible to complete a course without dependency on the instructor as the main source of information. Students can learn on their own, when and (sometimes) where they like, and at a speed that is comfortable. This contrasts with what we've described as a mixed model which involves instructor-centered teaching with some adaptive components (e.g., contracting, projects, etc.); and with the nonadaptive--the conventional college teaching methods, in which all students are essentially treated the same.

Which model is for you? Is it the one that you're using now? Remember, the theme of this manual is adaptation--which, when applied here, reminds us that no single teaching model is best for all instructors under all circumstances. The authors, for example, use different mixed model orientations in several courses, and a full adaptive approach in another. It is hoped that this section has prompted you to think about the methods that you're using, and to consider possible options. In the following chapters, we will examine more specific adaptive methods and their strengths and weaknesses. At worst, you will become more informed about the "state of the art" in this area; at best, you'll not only be informed, but will discover useful information that can be implemented in your courses.

We'll start first with a "pioneering" method that is still quite popular--programmed instruction. The method that is currently the most popular in higher education will then be considered next--Personalized System of Instruction. Last to be considered is the sleeping giant, whose potential far exceeds that of any other system--Computer Assisted Instruction (CAI).

CHAPTER II

Programmed Instruction: A Pioneering Method

Programmed Instruction (PI) was developed by B. F. Skinner in the mid 1950's. It was a highly creative and promising idea, which comprised a direct derivative of Skinner's scientific work on learning. So that you can appreciate the thinking involved, we'll quickly run through the influential learning principles and their PI correlates.

1. People learn at different rates. Given this idea, it is only natural to propose a system where "slower" learners can work at (what else?) a slower pace, and faster learners at a faster pace.

2. Reinforcement is a powerful determinent of learning. We all know that people are more likely to do those things that are rewarded. This principle suggests the importance of creating conditions where reinforcement will be frequent. How might this be done? Ask relatively easy questions at first, then build up slowly to harder, more advanced concepts. Each correct response is reinforcing. With each reinforcement, new learning occurs, and the cycle continues.

3. Learning is promoted by activity. The suggestion here is to get the student involved as actively as possible in the learning process. Reading a response is less effective than constructing (i.e., actually giving) one. Therefore, create conditions in which students will continually be giving overt response. Ben Franklin best summed it up by saying: "I see and I forget; I hear and I remember; I do and I understand!"

4. Immediate feedback is helpful for learning. What good does it do if students give a response but must wait a week to find out whether they're right or wrong? People prefer to know the results of their actions as immediately as possible. Immediate feedback serves two purposes:(a) if your response is correct, you are reinforced and are more likely to remember the answer, and (b) even if your guess is incorrect, you leave knowing the correct response. This seems to be a major reason behind the success of TV quiz shows and electronic games--the feedback is immediate and serves to reinforce additional behaviors. So by giving knowledge of results or "feedback" immediately after a response is given, we're intervening at a time when the response is fresh in the student's mind, there's interest in the task, and bad habits have not yet been formed.

5. Develop new skills gradually through small steps. Skinner's term for such modification is "shaping." The essential idea is that you can't take a person from State X (confusion) to State Y (expertise) all at once. Many of us fail at projects because we attempt too much at first ("Tomorrow I will save the world") then, when we fail at our unrealistic goals we become frustrated and give up. Instead, we should take smaller steps and thus allow for more successful experiences. When teaching students, we should begin with material that offers a high probability of success, reinforce it, repeat it, and then introduce something a bit more advanced. The shaping we do should maximize the thrill of victory and minimize the agony of defeat.

Components of PI

The above ideas culminated in the development of the learning frame--the backbone of PI. Learning frames present small units of information at a time. Blank spaces are interpersed in the frames, with the expectancy that students will write in the answers ("active responding") as they proceed. As answers are given, the student repositions a cover sheet to expose the correct answers ("immediate feedback"). The questions are geared to elicit correct answers ("positive reinforcement") by taking into account what the student should know at that time. Subsequent learning frames will repeat some of the original information and use it as the basis for introducing new concepts. Progression to new skills is systematic and slow ("shaping"). Students progress through the frames at whatever rate they consider comfortable ("self-pacing"). An excerpt from a programmed lesson that the first author wrote (to teach methods of PI of all things!) can be seen in Figure 1. Notice how it incorporates the above features. Try to form an opinion as to how this orientation would work for your students.

The program shown in Figure 1 is a linear one because all students encounter the frames in an identical sequence. A more complicated type of programming involves branching programs. The procedure, in brief, is to direct students to different frames depending upon the nature of their responses. For example, after answering a multiple-choice question following Frame 1, the student is

Programmed Instruction

Overview and Directions:

The purpose of this exercise is to have you learn about programmed instruction by actually experiencing it. The procedure will simply involve reading through the program that follows and making responses (to yourself or on paper) whenever a blank appears. Since it is strongly requested that you not write on this form, you should take out a piece of notebook paper so that it will be available for recording responses or taking notes (no lecture on programmed instruction will be given).

Note that the program is divided into two sections, text on the left and answers on the right. It is suggested that as you read the text, you cover the answers with your notebook paper. When a question is asked, see if you can answer it yourself. Then move the answer sheet down to determine whether your answer matches the one given.

Here we go: this promises to be unbelievable fun and educational too!!!

1. Remember operant conditioning theory? It was developed by B.F. Skinner. Skinner is well known for his development of _____ _____ theory.	operant conditioning
2. Operant conditioning theory supported a number of assumptions about making learning effective. One was that punishment is less effective than positive reinforcement. Therefore, a good instructional strategy would be one which creates many opportunities for _____ _____.	positive reinforcement
3. Another operant conditioning idea was that learning should be active or overt. A good strategy, then, is one that solicits active or _____responding from students.	overt
4. Aside from increasing opportunities for reinforcement and making learning active, a good strategy should present information in a logical order. Instruction should be carefully _____.	sequenced
5. Given these assumptions, the idea of "programmed instruction" was suggested to B.F. _____ and developed by him in 1954. Contrary to popular belief, Skinner did not develop the first teaching machine. That was done by Sidney Pressey.	Skinner
6. Programmed instruction incorporated the idea of creating many opportunities for _____ _____. That is done by making questions easy and repetitive as we are doing here.	positive reinforcement

Figure 1: Sample Program

told to advance to Frame 2 if he answered A, but to branch to Frame 24 (remedial) if he answered B, and so on for other alternatives. Enough about different programs. Take another look at the figure, and skim through the program. What is your opinion about the desirability of this approach for your teaching? See if your feelings are consistent with the following analyses of strengths and weaknesses.

Strengths

Here's a listing of perceived strengths based on the authors' interpretation of the literature and personal experiences as PI users.

1. PI is a good way to accommodate individual differences in learning rate.
2. It seems excellent for teaching difficult, technical material (e.g., as in physics, math, etc.) due to the slow and systematic presentation of material.
3. It seems excellent as a device for remediation. For example, a teacher might prescribe programmed lessons to students having difficulty with particular units. This contrasts with the common situation in which no remediation is available other than rereading one's notes or the textbook.

Weaknesses

1. Programmed lessons are difficult and time-consuming to write.
2. Some students, especially high-achievers, find the lessons boring due to the considerable redundancy and slow progression.
3. The PI format seems to emphasize learning of terms, names, and facts rather than meanings. It may promote short-term, rote learning rather than long-term, conceptual learning. Students may get the idea that if they can fill in the correct answers, they "know" the material. (Information not tested in the program may be considered unimportant and ignored.) PI, in general, seems best suited for teaching specific knowledge rather than developing higher order skills involving comprehension and analysis.
4. PI is an instructional resource (much like a textbook) not a management plan for individualizing your course. If you use it, what you've essentially accomplished is to allow students to complete certain lessons at their own pace (under the special PI format). Questions regarding how to introduce those lessons and integrate

them effectively with other course procedures (e.g., testing, grading, lectures) are left to the instructor to resolve.

Status

Following Skinner's introduction of PI, considerable interest was generated among educators. But its actual impact turned out to be substantially greater in the military than in higher education. A tangible outcome during PI's heyday in the 1960's was the availability of many college textbooks written in programmed form. Most instructors, however, were content to continue using conventional books. Today, programmed textbooks still exist, but their incidence is much less. PI is a great idea theory-wise, but it simply did not catch on to nearly the extent expected. In the military, however, it's a different story. Students typically enter with lower aptitudes than their college counterparts. Thus, the slow, systematic format of PI seems well suited to their needs, particularly for learning technical information.

Research on PI does not leave us with any firm impressions of its effectiveness. Where comparisons have been made between learning from PI lessons and lectures, some favor one, some the other, and many neither. The same goes for student attitudes--nothing conclusive. It seems likely that a good PI lesson can be very helpful but much depends on the objectives to be met, student characteristics, and so on. The decision of whether and when to use PI must remain a subjective one. If you like it, and are willing to spend sufficient time developing materials and/or procedures, it will probably serve you well.

Recommendations

In closing, some recommendations will be offered based on the authors' opinions.

1. If you do not feel comfortable with PI, do not feel an obligation to use it.

2. Use PI primarily as a supplement to other resources, not as the primary mode of instruction.

3. If you enjoy such activities, develop your own PI lessons, rather than using existing ones. Pick an area of your course that is presenting the most difficulty for students, and use that as the focus. Try it out, evaluate student reactions, and then revise and try again.

4. If you have no inclination to write your own PI's, see if you can find existing lessons or textbooks covering topics that you teach. Try them out with students and note reactions.

5. Are you ever searching desperately for special (extra credit) projects for students? If you like PI, students might have fun writing programs as projects. They not only learn from the experience, but you end up with a potentially useful product.

CHAPTER III

PSI: A Management System in Individualized Instruction

In this chapter, we will consider an approach developed a few years after programmed instruction. The developer was F. S. Keller, a follower of Skinner who had some interesting ideas for individualizing learning. Keller's interest was with higher education, and so his orientation was designed with the college student in mind. Like Skinner, he was influenced by operant conditioning (reinforcement) theory. But where Skinner tried to translate theory into very detailed instructional procedures (i.e., the different components of "learning frames"), Keller was concerned with a more general type of application.

What was Keller's rationale? Experiments in operant learning theory plainly show that animals (and humans too!) will make responses to obtain rewards. In fact, many of them will work very fast if they perceive rewards to be directly contingent on those responses. Applying this to teaching, we must concede that lecture-type classes offer only limited opportunities for individual initiative to operate. Students work pretty much according to the schedule that the instructor sets. Also, so much might seem to depend on "chance" factors as far as one's grade is concerned (whether the test was hard, the distribution generous, the instruction adequate, etc.), that little incentive exists for doing anything different from one's classmates. Since college students have reached a mature level (relative to most other type of students) why not put them in charge of their own actions? Establish the contingencies for success, make the necessary resources available, and set them loose to determine their own fate. Such is the thinking which influenced Keller's model. If it is not clear at this point, it should become so as you

consider the different components of the method known as the Keller Plan, Personalized System of Instruction, or most simply PSI.

Components of PSI

1. Go-At-Your-Own-Pace: This is the central core of PSI. It is what it says: the opportunity to complete a course as fast or as slow as you like (within realistic limits, of course).

2. Unit Perfection Rule: What determines how fast students progress through a course? The answer is how fast they complete (master or perfect) the component instructional units. "Perfection" is not to be taken literally, but rather will depend upon what individual instructors decide to be a satisfactory performance. That subjective feeling should be translated into an objective criterion, though, to systematize evaluation. Commonly, levels such as 80% or 90% correct on a unit test are selected as cutoffs. There is no hard and fast rule. How difficult is your subject? What are your personal standards? What level of proficiency seems prerequisite for progression to subsequent units? These are the type of questions that should influence the decision as to whether 80, 90, or even 100% (real perfection) is the best choice.

3. Use of Proctors: For some instructors, it might seem like some kind of pedagogical nightmare to have 20 or 30 students proceeding through their course at all different rates. The first two PSI components, necessitate that frequent testing and immediate scoring must be provided. Why? Because any delay in these functions essentially places students on "hold." They can't move forward until they have been credited for the present unit. Delays destroy the spirit of PSI and get students into the habit of not doing their work. The component being presently considered "use of proctors," is a practical solution to the problem. It involves "employing" former students as assistants to help with testing and instruction. Former students benefit by continuing their contact with the subject matter, and by gaining some applied teaching experience in the process. The benefit for the instructor is obvious--much needed assistance in running the course. Even present enrollees benefit by having the chance to work with someone in the peer group, who may be able to do a better job at explaining things than the instructor (who is more knowledgeable but farther removed from the learner's experiences). How does one entice these former students into their apprenticeship? The authors have found that just being asked is tremendous reinforcement for some, and they are willing to help out just for the experience. A fairer, more business-like way is to offer the assistant "special projects" course credits that are usually available in most departments. That way, students get formally recognized for assisting in the course through credit on their transcripts.

4. Stress on the Written Word: This fourth component concerns the mode of instruction. While it might be comfortable to adopt PSI while continuing with a usual lecture/discussion format, such

is not possible. Lecture is poorly suited to a "go-at-your-own-pace" system. No matter what you lecture on (unless it's the very first unit), you're going to have people who have already completed that material, and others who aren't ready for it yet. Could there be an occasion where everybody can benefit from a lecture? Of course... there might be a special topic that can best be presented to an entire group. But lecture is not the main vehicle that drives PSI. Written materials, such as a combination of textbook readings, instructor-developed outlines and manuals, and commercially produced programmed materials might be ideal. The obvious advantage is that written material can be carried around and studied at one's convenience. It can be reread over and over if more repetition is needed. Such qualities are clearly consistent with the PSI procedures and objectives.

Can other resources besides written material be used? Yes! The more the merrier, as long as they are helpful to students. For example, resources for a particular unit might include a textbook assignment, a filmstrip, an audio-tape, and/or computer assisted instructional tasks (discussed in the next chapter). But, the written presentation will probably be the main choice in the majority of instances.

5. Criterion Referenced Testing and Grading: Criterion-referenced testing used in PSI, places the student's evaluation on the basis of whether certain prespecified standards (e.g., 80%) are reached. In contrast, norm-referenced testing bases the evaluation on a comparison to others. The latter takes control away from the student since students can "master" all competencies, but still fall short of some of their classmates. The result might be a grade of C for what is actually a pretty good performance. Grading, as well as testing, is criterion-referenced under PSI. One procedure is to base grades solely on the number of units successfully completed (e.g., 8 units=A). A second procedure makes the determination according to total test points earned (e.g., 640 points=A). A third requires students to complete all units, and bases final grades on the average unit scores (e.g., $\bar{X}$ of 90=A). The choice is yours, but note again how these procedures place the responsibility for grades more firmly under student control.

6. Retesting: The mastery learning approach stresses the importance of making retesting available for students who have failed to reach criterion. Thus, several parallel forms of each unit test need to be constructed. When course grades depend on number of units completed, retesting is generally permitted without penalty. When course grades depend on number of points or average grade, some penalty is usually invoked to discourage retesting as simply a means of increasing one's score. For example, where test grades are assigned, a grade of B may be established as the maximum for the first retest, and a grade of C as the maximum for any subsequent retests.

Perceived Strengths of PSI

As was done for programmed instruction, we will now examine the strengths and weaknesses of PSI from the authors' points of view. The first author's experience dates back to 1974 when he was confronted with what seemed to be an impossible teaching mission. That was to develop an undergraduate statistics course for education majors to be taken as an elective!! What student in their right mind would opt for that sort of "treatment" when attractive, easier electives like Driver's Education were available? The answer was"very, very few." Two semesters of advertising and conducting a lecture-type class produced limited student response and little promise that results would change sufficiently to save the course. With the ship destined to sink anyway, there was nothing to lose by experimenting with this new method called PSI. Considerations were that (1) even an unpopular subject like statistics might appear attractive with take-home, self-study lessons, and (2) much of the threat normally associated with statistics courses might be removed; students could progress at their own pace; receive one-to-one tutoring; retest to their heart's content; and so on. Advertisements were distributed using attempts at Madison Avenue style allurements (e.g., "NOTICE: THE FIRST DAY OF CLASS WILL BE THE LAST DAY OF CLASS: READ ON!").

The strategy worked. Over the past six years, enrollment has increased to the present level of almost 100 students a year. About half of the enrollment stems from the course having been made a requirement for certain programs, but the other half of the enrollees, mostly from education, take the course as an elective. Staying with a conventional format would not have produced the same results.

An instructor's experience with PSI will involve a trade-off between preferred aspects of its methods and of those formerly used. In the author's

case, overall preference for PSI (for that course) has resulted for the following reasons:

1. PSI is ideally suited for students whose situations make it difficult to attend regular classes (e.g., those employed fulltime or living far from campus).

2. It removes a great deal of the threat associated with courses like statistics through its components of self-pacing, retesting, tutoring, etc.

3. The self-pacing component allows high-achievers to complete the course early, an attractive option for them, while freeing the instructor to devote more time to low-achievers.

4. It provides opportunities for instructors to work with students on an individual basis and thus experience closer contact with the material and learning process.

5. It often provides a welcome relief from the convention of lecturing.

6. The use of course proctors is an excellent vehicle for furthering learning experiences of former students.

7. As will be reported in more detail a little later, research on PSI has produced very supportive results regarding its effects on learning and attitudes.

With all these advantages, why wouldn't everyone rush to convert their courses to PSI? Well, there's always the other side of the coin--negative features, which we'll consider next.

Disadvantages

1. Student procrastination is a problem. It appears that some students simply lack the skills for self-management, and would be better off in a situation where the instructor makes most of the decisions for them.

2. Preparing written instructional material requires considerable initial work and is an ongoing (and ongoing...) burden.

3. Paperwork involved in testing/grading is much more extensive than in a lecture class.

4. One loses the control and ego-fulfillment that being "center stage" in a lecture class can bring.

5. The emphasis on mastery scores (the old 80% criterion) may result in students working just to reach that level and not putting forth their best effort. If such does appear to happen, incentives can be built-in for exceeding the mastery level (see grading alternatives discussed previously, p.15).

6. PSI appears best suited for highly objective content such as in math, chemistry, engineering, etc. The author, for example, is quite satisfied with using it for teaching statistics, but would be reluctant to do the same in his educational psychology course in which a great deal of the emphasis is on experiential learning and class discussion.

Reactions to PSI will differ from instructor to instructor. The above experiences, nonetheless, relate what should be fairly common perceptions. PSI is not "better" than lecture-discussion, it simply supports different types of activities and outcomes. With regard to outcomes, how has PSI fared when compared to other methods? Has it actually been compared? The answers, in brief, are "well and yes." More details follow below.

Status

PSI has been the subject of numerous investigations. Fortunately, two recent reviews of the literature, one by Robin in 1976 and the other by Kulik, Kulik, and Cohen in 1979, make the task of consolidating findings considerably easier. Here are the major results:

1. When PSI and conventional classes have been compared on course achievement, findings have overwhelmingly favored PSI. Specifically, the PSI class mean achievement was higher than the control class mean in 30 out of 39 cases reviewed by Robin and 57 out of 61 reviewed by Kulik et al.

2. Both reviews report equally impressive advantages for PSI on student ratings of instruction.

3. The reviews reveal increases in the number of A and B grades awarded under PSI, an expected product of criterion-referenced grading.

4. On two outcome variables, however, there is disagreement. Those in question are study time and course withdrawal. Robin's review indicated that PSI students spend more study time and have a higher course withdrawal rate than do students in lecture classes. Kulik et al.'s review indicates no difference between methods on either variable. For whatever it's worth, the first author's experiences with withdrawal rates are more suggestive of the "no difference" conclusion. Withdrawal from his PSI course is about 10%, close to the rate for his lecture course.

Such results look very favorable indeed. But some of our more cautious readers might question who did these studies and is it really possible for one instructional method to be crowned superior to another? We share such reservations, feeling once again that the relative benefits of PSI versus lecture depend on your goals for the course--and numerous other variables. But what about the research findings? Clearly, they are encouraging for PSI. But, we must avoid forming definite conclusions for the following reasons: First, it is traditional for journals to favor the publication of studies that show differences between treatments over ones that do not. It is possible, then, that lecture and PSI outcomes are much more similar than different. (That is, studies showing similiarities just don't appear in journals as often!) Second, we need to consider the researchers themselves and the fact that many were personally involved, either as instructors or designers, with the very PSI courses evaluated in their studies. Were the lecture courses, used for comparison, conducted with the same enthusiasm and involvement? Maybe not. Third, it is possible that PSI owes its success to several isolated properties like frequent testing and specifying objectives, rather than to any intrinsic superiority over lecture. The literature thus presents a positive but perhaps somewhat exaggerated view of PSI's effectiveness. But, even with the most cautious interpretation of findings, PSI still emerges as an attractive teaching option worthy of your consideration.

Recommendations

1. Introduce PSI gradually rather than all at once. For example, select a content area in which student self-pacing seems especially useful. Develop/select materials and assign that area as a PSI lesson that can be completed at one's own rate and evaluated according to mastery criteria.

2. If you like the results of the above restricted try-out, gradually turn more lessons into PSI ones. Eventually, the entire course can be run as PSI, if desired.

3. To get started with your first PSI lesson, do the following:

a. Break the lesson down into specific instructional objectives. Example: "Student will be able to compute the mean of data"

b. For each instructional objective, construct or obtain instructional material that will teach the appropriate content.

c. Construct posttests whose content covers all objectives. Parallel tests (maybe three or four) will be needed for each unit to permit retesting.

d. Replace lecture classes for the unit with "laboratory" sessions that students can attend to take tests or receive help. Remember, PSI doesn't involve abandoning students. The availability of help sessions is an essential component. In the beginning, you will have to handle all work on your own. Over time, you can explore possibilities for employing course tutors. Regardless of the set-up in your school, there should be some way of formally involving former students in those functions.

e. Develop a detailed outline that specifies the way the system works, the recommended resources and pacing rates, and all the rules. The author's course outline is 6 single-spaced pages; the outline that Keller presents as a sample in one of his articles is even longer. In lecture classes, you have the benefit of being able to continually remind students of procedures; in PSI, you don't. Clear, detailed directives are essential.

f. Try the unit out, revise, and try again. Successful PSI materials are not created overnight--they take time.

4. As a final note, we should deal briefly with the most frequently voiced PSI problem--student procrastination. If it is not a problem for your students, no need to change a thing (but consider yourself fortunate). If it is a problem for a significant number of students you may want to reconsider the "total freedom" idea as a desirable pacing rule. Perhaps some restrictions are needed to get the procrastinators on track. Some suggestions are:

a. Impose deadlines for the first few units. This gets everybody in the habit of working on the material from the beginning. It reminds them that they are taking your course! It also prevents anyone from getting so far behind that a good course grade is not possible.

b. Allow only so many units to be completed during the last few weeks of the term. Some students try to complete an entire course just before the term ends. They may pass your tests, but it's hard to believe they have learned the information nearly as well as someone who has taken more time to assimilate each unit.

c. Offer the option of (or require) having a pacing schedule constructed in advance of each test through consultation between the student and the instructor. Some students are perceptive enough to admit that they do better when they're committed to a deadline, and request such schedules on their own. Why not make them available at the front end?

d. Offer incentives (extra credit, exemption from final exam) for faster completion rates.

5. Keller suggests that there should be no deadline for course completion. Opportunity to receive credit and any grade exists as long as students are willing to take "incomplete grades" and pay enrollment fees across semesters. The idea is that a competency is a competency regardless of when it's completed--so don't feel the necessity of restricting course completion to one semester only. That is Keller's opinion, and there is certainly merit to his rationale. The present authors, however, prefer to restrict course completion to one semester. The rationale is that:

a. Certain concepts are prerequisite to others and will be forgotten if course completion time is extended across semesters. The student will continually have to relearn already completed units--and thus gets caught in the treadmill of getting farther behind each time he attempts something new.

b. At some universities, the bookkeeping involving incomplete grades is awkward and time-consuming. Having large numbers of students continuing courses across semesters can be an administrative nightmare, requiring written justifications, mid-year grade runners, and so on.

c. The people who get incomplete grades tend to be the procrastinators we talked about earlier. Allowing them the option of completing a course whenever they desire provides optimal conditions for procrastination, and thus may only accentuate their problem.

In summary, PSI has a solid rationale and excellent marks from evaluations. It may or may not fit your plans, but should, nonetheless, be something to keep in mind as a possible method for your course.

CHAPTER IV

CAI: Promise for the Future

The last method to be considered is hardly least in terms of its potential. It's called computer-assisted instruction or most simply, CAI. The idea of using the computer for teaching is not new. The major problem has been the absence of hardware (computer equipment) and software (instructional programs) to make CAI accessible and functional. But the situation is rapidly changing. Now, for $1000 or less, families can purchase their own computers (these units are called microcomputers) for use at home. For considerably less money (around $25 or so) they can purchase "programs" ranging from computer games to educational packages. What this means is that cost-wise, CAI has now become a reasonable option in higher education. Recognizing that at this point, few instructors have used CAI for teaching, this chapter will try to acquaint you with the basic components and possibilities.

Components of CAI

The basic set-up of a CAI system first involves having a computer (no surprises here!). One alternative is a large, time-sharing system as is found at universities and many colleges--in other words, what faculty refer to as the "main computer." If your school has one, you're off to a good start. If it doesn't, the expense involved is sufficient to prevent them from acquiring one just for your CAI interests. Another option is microcomputers. These are small, self-sufficient units that can be purchased for very reasonable cost. A third option is to use someone else's main computer through a sharing system such as EDUNET. What happens is that your institution pays a fee which entitles them to access computers at "supplier" schools. Presently, members can use computer services at suppliers such as Stanford, University of Minnesota,

Carnegie Tech. and many others, just by dialing the phone and "connecting" those computers with terminals in their classrooms.

Given that a computer is available, what else is needed? Think of a computer as only a brain. It can analyze information and make it available, but, by itself, lacks a communication system. In other words, you need some way of communicating what is in the computer (brain) to those interacting with it (people). The mechanism typically used is a monitor which looks like or may actually be an ordinary TV set. If you're using a main computer, the monitor will be "hooked-in" by phone (using a modem unit). The same is true under a computer sharing system like EDUNET. For a microcomputer, the monitor may be wired to the computer or actually be part of the same unit. In any case, if you're unfamiliar with computer usage, picture someone sitting in front of a TV screen reading information from it. If the screen sends information from the computer, how do you send information to it, i.e., tell it what to do? Another important piece of hardware which may be separate from or attached to the monitor is the keyboard--just picture a conventional typewriter.

So, regardless of what type of computer we're using, the basic set-up is as follows: We're sitting at a terminal typing information as input to the computer, and receiving information as output on the monitor. How do we know what to type in, and how does the computer know how to respond? That leads to issue of software.

Software constitutes the programs or routines that are stored in the computer. The programs tell the computer how, and with what information, to respond. The computer games advertised on TV for playing chess and shooting down space invaders are examples. They are sets of instructions that tell the computer what to do. Users of CAI do not have to be able to write

programs. All they need to know is how to run them--which is analogous to working one's stereo system, tape recorder, and similar everyday types of equipment.

So now we have our image of people interacting with the computer via the keyboard, monitor, and program (the software). What other types of equipment might be found? Here's a brief summary.

1. Line printer: This device, which looks like an overgrown typewriter, provides a printed copy of information that would otherwise appear on the monitor. It can be used independently or together with the monitor. The advantage of a printed copy is obvious--since what disappears from the monitor each time a new display is presented may not be retrievable immediately. The disadvantage is that printing is much slower and paper is being consumed for displays that you may have no interest in viewing.

2. Touch sensitivity. Some units are touch-sensitive so that just touching the monitor sends information to the computer. This is extremely valuable in CAI since a child can point to (touch) a response on the monitor rather than typing words.

3. Audio capabilities. There are devices that permit computers to make sounds, play music, annunciate words. Think about the advantages for teaching subjects like music, foreign language, and reading. There are many.

4. Word processing. Word processing units are expressly designed to facilitate writing, editing, and the production of copy. Text can be composed, edited, proofread, and produced at the computer terminal in a fraction of the time it takes using typewriters and conventional methods. This is not CAI, but nonetheless an attractive labor saving device for instructors involved in writing and publication.

5. Graphics. Computers can display and facilitate creation of very complex graphics in an array of colors. Such is extremely valuable for simulations. For example, in auto mechanics, an operational engine with pistons pumping and gasoline flowing can be depicted on the monitor. Students can interact with the engine, and learn about it, without the muss and fuss and expense of making real engines available.

Now that we've given you an idea, and a very general one at that, of computer input/output capabilities, let's examine the components of a CAI learning system that differentiates it from, say, PSI.

First, CAI is interactive in the sense that the computer can ask a question, and then follow up with information geared to the student's response. PSI, when using printed material, is static. Everyone gets the same information in the same order.

Second, CAI is generative in the sense that it can produce limitless numbers of exercises in certain subjects. True, in a subject like history, the computer can output only what is put in. But for math, it can generate random numbers and insert them in a standard problem format (X/Y = W), so that each solution is different. The student can ask for as many problems as he/she wants. The computer has infinite patience and stamina. For other subjects, the teacher (or programmer) must enter in the specific questions, but the number stored can be increased over time. The result may be 100 different questions on the Civil War. Students can "drill-and-practice" on as many of those 100 as they like--an efficient and neat way of adapting the quantity of instruction to learner needs. PSI, of course, makes the identical set of material available to all students.

Third, CAI is flexible in that it can offer instruction in several different modes, according to student preference. Say, students are learning about velocity in physics. The computer may allow them to switch between diagrams, text, formulas, and sample questions illustrating the principles. In a conventional situation, teachers can alternate these modes, but never in a manner that suits everyone's learning style at the right time.

Fourth, CAI can be prescriptive. Programs can be written that keep track of student progress, and make recommendations--based on past and recent performances--or how and what to study.

Fifth, CAI offers numerous possibilities for adaptation. Noted above are those concerning mode (type) of learning, pacing, and quantity of instruction.

Other possible forms of adaptation include amount of control over learning (having student choose what is presented as opposed to having the teacher or the computer make the decision), testing (challenging items for advanced students; easier items for beginners), variations of incentives (higher incentives for more difficult materials to focus attention on their learning), and selection of theme (e.g., baseball vs. marketing as a context for learning math concepts).

As can be readily gathered from the above, CAI presents many exciting possibilities for individualizing instruction. Excitement, yes, but what about results? Is CAI a good way to teach? Again, the answer must depend on what you want to accomplish. Here's a summary of our perceptions of CAI's strong and weak aspects.

Strengths

1. It is difficult to think of a better vehicle for drill-and-practice. Students can sit at the terminal and receive all the practice they need without having to depend on the physical presence of their teacher.

2. CAI is very effective for simulations, e.g., the gasoline engine discussed earlier. What can't be demonstrated in class can probably be simulated via CAI. Examples the authors have seen are the workings of a nuclear reactor, conditioning a rat in a Skinner Box, breeding of fruit flies to illustrate genetic principles, illustration of trajectories in physics, refraction of light by a prism, and many others.

3. CAI is an excellent management and record-keeping device for courses.

4. CAI offers an attractive alternative mode as a change from accustomed learning procedures (lecture or something else).

5. CAI fits very well into a framework like PSI. Once a PSI system is developed, CAI can be readily incorporated as an instructional resource supporting selected learning objectives.

6. CAI optimally supports student differences in learning rate. If appropriate CAI programs are available, it is easy to have students working on different lessons according to their present needs. For example, the especially bright student in a statistics class can be studying an advanced unit on analysis of variance, while other students are working on more basic units.

7. Students enjoy interacting with the computer.

Disadvantages

1. Presently, CAI is still expensive relative to conventional teaching. One computer terminal can hold only one student at a time. Thus, CAI--if made an integral part of a course--involves a relatively large initial expenditure.

2. Equipment failures ("computer downtime") are irritating and, if frequent, can create real problems with your schedule. When the university computer is "down" (at whatever time it goes), so is instruction in your course. With microcomputers, each unit is independent, so if one breaks, the show still goes on. (Although teachers have been known to break down, they do so with less frequency and more advance warning than computers.)

3. While computers can do wonderful things with graphical displays and sounds, some students find them inefficient or awkward to use for reading text. A textbook contains a complete set of material in a relatively small, manageable package. Each page can contain a substantial amount of print--and you can hold the book at any distance to make the page easiest to read. In contrast, the computer terminal presents a relatively small display. "Paging through" different sections and making out what is written is less convenient than in a book. If a line printer is the only output device, the situation is even worse. One must sit there and read at the pace that a typewriter actually prints the material. It's slow and frustrating--and not an optimal use of CAI. In summary, when there is a lot of reading, CAI seems less suitable than programmed manuals and conventional textbooks.

4. CAI refers only to a system. The quality of what is taught through CAI depends upon the quality of the lesson ("software") presented to students. Unfortunately, the hardware aspects of CAI have advanced much more rapidly than the softward aspects. An instructor who wants a lesson on, say, isotopes in chemistry may not find one available that meets his needs. On the bright side, interest in instructional programming is rapidly growing. More of the book companies and microcomputer companies are developing programs, and making them available commercially. Different communication networks are now being formed (newsletters) through which new programs are publicized. Nonetheless, it still remains far more difficult to obtain CAI material than is the case for other types of learning resources.

   What are the options for CAI material? Here is a brief run-down: (a) Purchase already existing materials. Disadvantages are the expense and what you need may not be available. (b) Have programs written for you by skilled programmers at your school. A disadvantage is that such individuals, assuming they exist, may not have the time needed to develop quality programs. Also, if you are inexperienced in programming and/or the programmer inexperienced in teaching, there may

be wide communication gaps resulting in poor quality work. (c) Write your own programs. This is a most enjoyable endeavor if you are so oriented. Many people are not, as the time investment in learning programming and in the actual writing is great. (d) Write your own lessons with the help of an "authoring" program. Most microcomputer computer companies make authoring programs available for relatively limited expense ($100-150). These are programs that walk you through the writing of a lesson--without your needing to know anything about programming. The main disadvantage, however, is that such programs are pretty much restricted to "drill-and-practice" routines; they do not provide much actual teaching. But, they do provide a start.

In light of the above and in summary, the absence of available software that does what you want it to do is a present weakness of CAI. The situation, though, is clearly getting better and better.

5. Different CAI systems (such as microcomputers) made by different companies are not compatible. Thus, you can have a whole set of programs, made for one system, that become unusable with a change in computers.

Status

CAI is currently the subject of much investigation. Results from new evaluations are continually being reported. But, as is the case for so many other instructional innovations, getting a perspective on the findings is a problem. One study, for example, may report significant achievement gains from CAI, but poor student attitudes. Just when you've restructured your thinking to accommodate that finding, you read the opposite conclusions from another study (poor achievement, but positive attitudes!). So much depends on who did the study, with which students, for what subject, in what context, and so on and on. Perhaps the most important thing is that the evidence to date is generally supportive of CAI as a teaching option (see Kulik, Kulik, and Cohen's review in the Review of Educational Research, 1980, Vol. 50). This is not to say that it's better than lecture; such a statement is too simplistic and an over-generalization of the findings. But, when carefully planned and implemented in courses, it has produced good achievement results and positive reactions by students and teachers alike. With better software, and more experience by educators, the outlook for further improvements must be viewed with optimism.

Suggestions

A common mistake by instructors is to regard CAI as an all or none proposition. Once you decide to adopt it, it becomes the only way to present material for your course. Not true! While some courses are run exclusively by CAI (e.g., courses at the University of Illinois using the PLATO system), it makes far more sense to regard CAI as a resource rather than an all-encompassing, "take-over" instructional mode. No one, for example, would expect you to teach your whole course by film just because you showed a film for teaching one unit. In our opinion, CAI should be thought about in the same way. Is there a place in your course where CAI (given its strengths and weaknesses) might be advantageous? If so, the next question to ask is how CAI might be used, e.g., by itself or as a supplement to existing resources for that lesson. If you're already using a PSI-type structure, CAI can be readily incorporated as either main or supplementary instruction. If you're using a conventional orientation, CAI can become valuable as a means of teaching/reviewing selected materials outside of class. If appropriate hardware and software are available (a big if, we agree, for some readers), adoption of CAI should be a very logical and straightforward procedure. Here are some suggestions for getting started:

1. Investigate the CAI facilities available at your institution.
2. Examine (ask for a demonstration of) any available programs in your teaching area. If no satisfactory ones exist, the question becomes, "can new ones be purchased or written?" If your institution answers no to these questions, then it is likely that your career as a CAI user will not blossom at this time (hopefully, this will be temporary). You can, of course, investigate purchasing programs yourself;you may find the benefit worth the personal expense.
3. If satisfactory programs are available, then introduce them in your course. Some work will be required, involving arrangements for:

a. sufficient computer time and classroom space to be available,

b. familiarizing students with operating the computer,

c. building in the necessary flexibility for equipment failure, and

d. integrating the CAI lessons and outcomes with your regular class procedures.

4. If microcomputers are available at your institution, it would be worth your while to spend a few days (maybe as a professional development activity) learning about their operation. Most brands come with self-instructional manuals that walk you through the procedures in a clear and straightforward manner. The result will be a familiarity with their capabilities, and (for some) a shedding of any anxieties experienced in viewing computers as complicated and mysterious entities. Perhaps, as what occurred for the authors, the result will even be a fascination with them and the discovery that programming languages capable of producing real teaching lessons are actually quite simple to master. When you reach that stage, the fun can really being. But at the very least, becoming familiar with what the computer can do is all you need to become a CAI user. Now is the best time to initiate that experience. Those who don't are going to find themselves more and more isolated from the growing number of people involved. The next generation of students will be ones who grew up exposed to computer games and CAI in their homes. Teachers unfamiliar with CAI and unwilling to take advantage of it in their courses are going to find it more difficult to catch up to and gain credibility with their students.

Closing Thoughts

We hope that this manual has provided a helpful introduction to adaptive instruction in higher education. If readers previously unfamiliar with different adaptative methods are now at least thinking about what they offer, and maybe of ultimately using them, we have definitely accomplished our purpose. For those not ready to go the full PSI route or make the commitment to CAI, perhaps the benefit will be recognition that isolated adaptive components, such as contracts, criterion-referenced testing, or a programmed lesson or two, can be readily incorporated within a conventional format and add a potentially helpful new dimension to your teaching methods. Those already using adaptive models are encouraged to compare their perceptions of strengths and weaknesses (of PSI for example) against ours. No two courses--and thus no two sets of experiences--will be alike, even if the overall orientations used are the same. But, everyone benefits when we consider the possible options (alternative methods) and try to identify those that work best for us and our students. That, as we have tried to convey in this manual, is what the concept of instructional adaptation is all about.